EE 221 Midterm Sol

October 23, 2003

1.

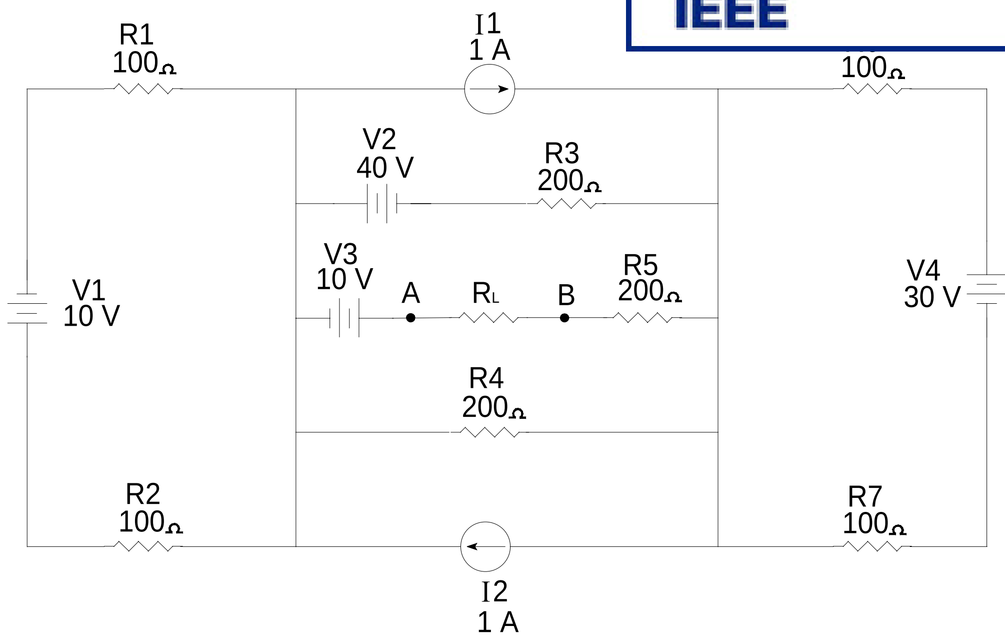

Figure 1

a) Determine and sketch the Thevenin’s equivalent circuit for the output terminals A and B.

Solution

First it would help to redraw the circuit to a more familiar layout.

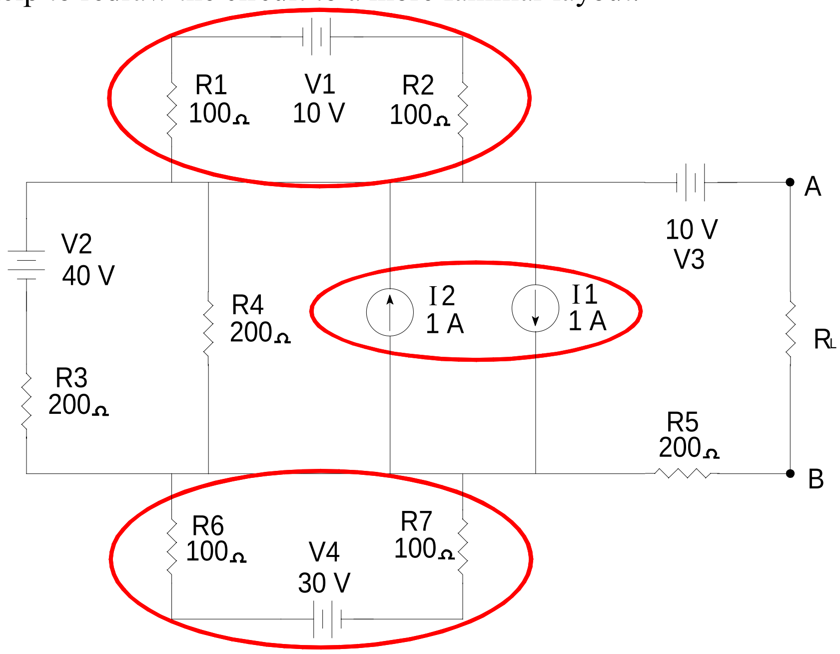

Figure 1a

After redrawing the circuit one should see that circuit elements V1, R1, R2 and V4, R6, R7 have no effect on the Thevenin’s equivalent circuit. As well current sources I1 and I2 cancel each other out. Therefore the resulting circuit to determine is shown in Figure 1b

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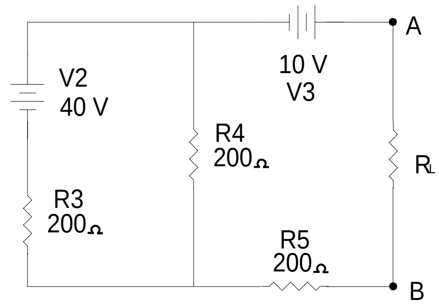


Figure 1b

Obviously the circuit is very simple and the resulting Thevenin's equivalent circuit is…

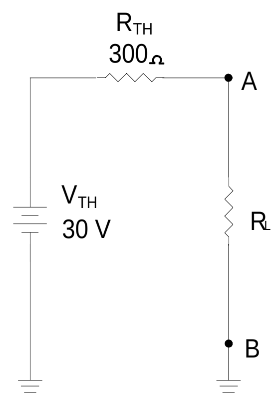


Figure 1c Thevenin's equivalent circuit.

Question 1 Continued

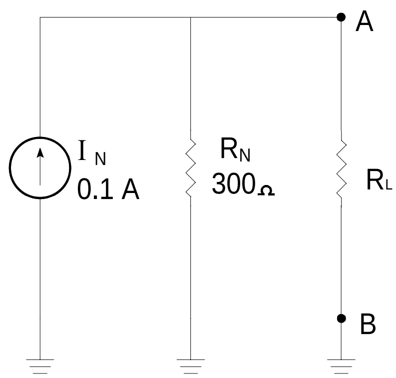
b) What value of load resistance would maximize power transfer?

$R_L = R_{TH} = 300\ \Omega$

c) What is the Norton's equivalent circuit?
(Provide a circuit sketch as well)

$R_N = R_{TH} = 300\ \Omega$

$$I_N = \frac{V_{TH}}{R_{TH}} = 0.1A$$



2. The output of the power supply shown in Figure 2 has a peak to peak ripple of 300 mV. What is the RMS output of the transformer secondary (total secondary)?

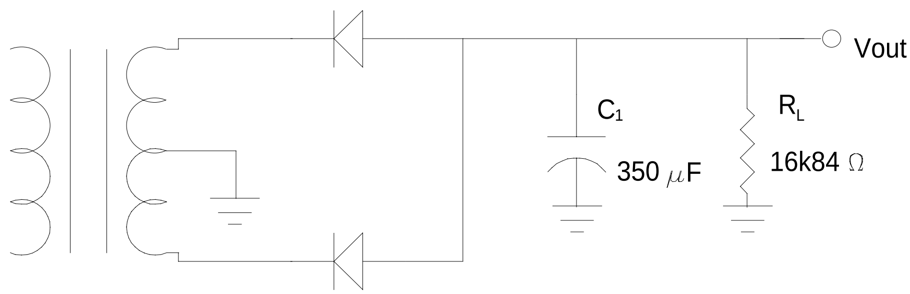


Figure 2

Solution:

$$C = \frac{\Delta Q}{\Delta V} = \frac{i_L T}{\Delta V} = \frac{i_L}{\Delta V F} \Rightarrow i_L = C \Delta V F = (350 \mu F)(0.3V)(120Hz) = 12.6mA$$

$V_L = V_P = (12.6mA)(16.84k\Omega) = 212.18V_P = V_P$ for ½ of the secondary or $212.88V_P$ if you included the 0.7 Volt drop across the diodes.

Therefore the Full Secondary voltage is 2 x 212.18 V_P = 425.77 V_P

And the RMS voltage is $V_{P\sec}/\sqrt{2} = 425.77V_P/\sqrt{2} = 300.07V_{RMS}$ or $301.06V_{RMS}$ if 0.7 V diode drop was taken into account.

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3. a) Why is the arrow on the BJT schematic symbol important?

   i) Determines the emitter leg.

   ii) Determines the transistor type (NPN or PNP).

b) The condition where an increase in base current will not cause further increases in collector current is called ________saturation________?

c) When a BJT has it's BE junction forward-biased and it's CB junction reversed biased, the transistor is ________correctly________ biased.

d) Draw the load line and determine the Q point for the transistor circuit. Assume β = 100, V_{BE} = -0.7 V, and I_{CBO} = 1 μA.

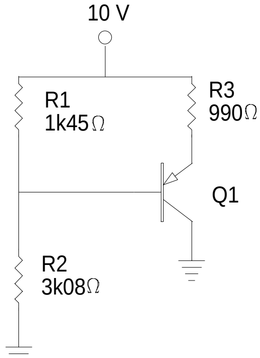


Figure 4

$$I_{C(Sat)} = \frac{V_{CC}}{R3} = \frac{10V}{990\Omega} = 10.1mA$$

$$V_B = V_{CC}\frac{R2}{R1+R2} = 10V\frac{3.08k\Omega}{3.08k\Omega + 1.45k\Omega} \cong 6.799V$$

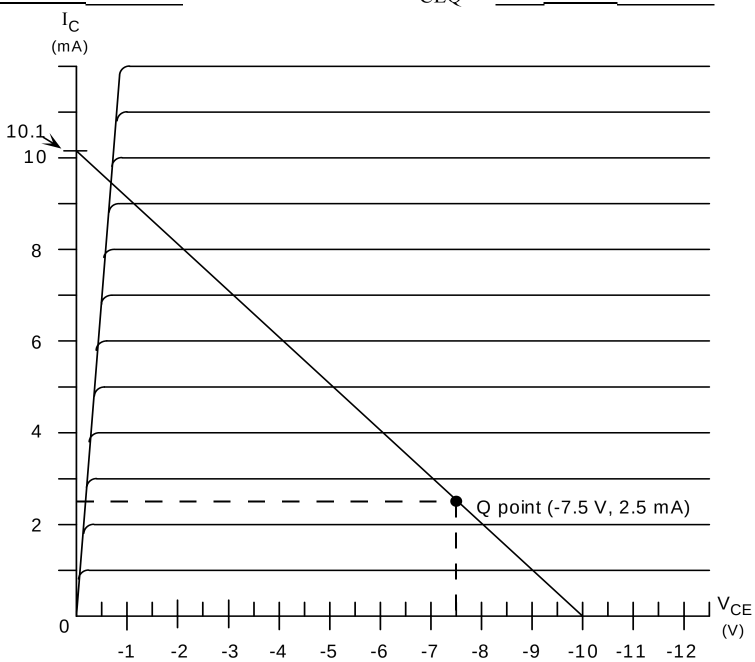
$$\therefore V_E = V_B - V_{BE} = 6.799V - (-0.7V) = 7.499V \cong 7.5V$$

$$V_C = 0V \Rightarrow \therefore V_{CE} = V_C - V_E = 0V - 7.5V = -7.5V = V_{CEQ}$$

$$I_{EQ} = \frac{V_{CC} - V_E}{R3} = \frac{10V - 7.5V}{990\Omega} \cong 2.525mA$$

$$I_{CQ} = \frac{\beta}{\beta+1} I_{EQ} = \frac{100}{100+1} 2.525mA = 2.5mA$$

I_{CQ} = ____2.5 mA____ V_{CEQ} = ____-7.5V____



4. Calculate all resistor values to place the transistors into the middle of their operating region for the circuits shown. Assume β = 100, V_{BE} = 0.7 V, and I_{CBO} = 1 μA.

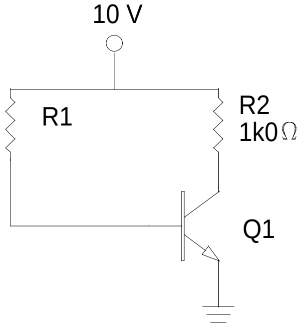


Figure 5

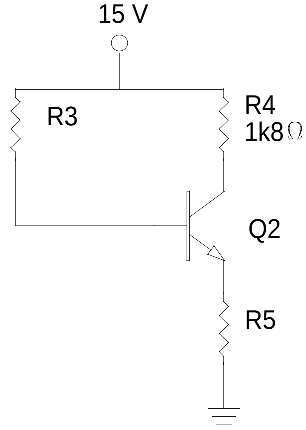


Figure 6

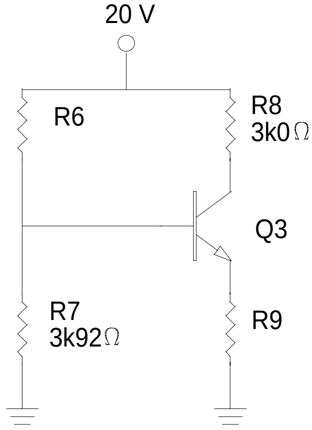


Figure 7

R1 = 186kΩ

R3 = 452kΩ

R6 = 12k76Ω

R5 = 1k188Ω

R9 = 1k98Ω

First you are designing these so you use the guidelines for quiescent voltages given in class. V_{CEQ} = ½ V_{CC}, if there are resistors in both the collector and emitter legs then you distribute the voltages as 0.3V_{CC} and 0.2V_{CC} respectively.

For R1

$$I_{CQ} = \frac{V_{CC}/2}{1k0\Omega} = 5mA \Rightarrow \therefore I_{BQ} = \frac{I_{CQ}}{\beta} = 50\mu A$$

$$R1 = \frac{V_{CC} - V_{BE}}{I_{BQ}} = 186k\Omega$$

For R5

$$V_{R4} = 0.3V_{CC} = 4.5V \Rightarrow \therefore I_{CQ} = \frac{4.5V}{1k8\Omega} = 2.5mA \Rightarrow \therefore I_{EQ} = \frac{\beta+1}{\beta} I_{CQ} = 2.525mA$$

$$R5 = \frac{0.2V_{CC}}{I_{EQ}} \cong 1k188\Omega \approx 1k2\Omega$$

For R3

$$I_{BQ} = \frac{I_{CQ}}{\beta} = 25\mu A$$

$$R3 = \frac{V_{CC} - V_{BE} - V_{R5}}{I_{BQ}} = 452k\Omega$$

For R9

$$V_{R8} = 0.3V_{CC} = 6V \Rightarrow \therefore I_{CQ} = \frac{6V}{3k0\Omega} = 2mA \Rightarrow \therefore I_{EQ} = \frac{\beta+1}{\beta} I_{CQ} = 2.02mA \Rightarrow \therefore V_{R9} = 0.2V_{CC} = 4V$$

$$R9 = \frac{4V}{2.02mA} \cong 1k98\Omega$$

For R6

$$V_{BQ} = V_{R9} + V_{BE} = 4.7V$$

Solving the voltage divider equation for R6 yields;

$$R6 = \frac{20V}{4.7V} 3k92\Omega - 3k92\Omega = 12k76\Omega$$

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5. **(Use the second approximation of the diode!)**

Sketch the waveform at each terminal, v_a, v_b, v_c, and v_{out} on the supplied graphs.
Note: v_{in} is 10 $V_{P\text{-}P}$ at 1 kHz and has been supplied on each graph as a reference.
Also determine the waveform at v_c without diodes D3, D4, Z1, and Z2.
i.e. As an intermediate step to determining the output.

Please try to be neat! A sloppy diagram may lead to a misinterpretation and lost marks.

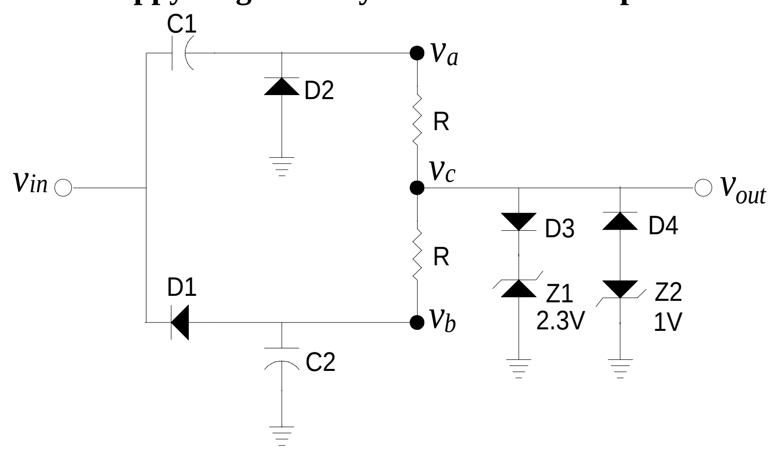
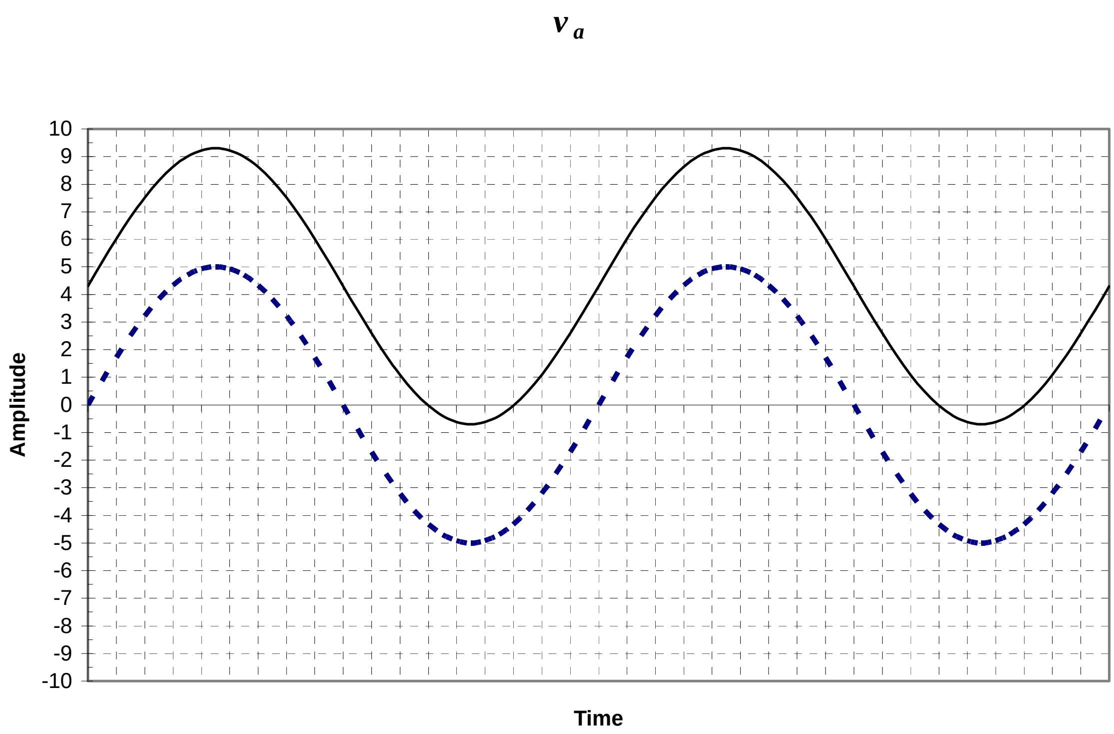
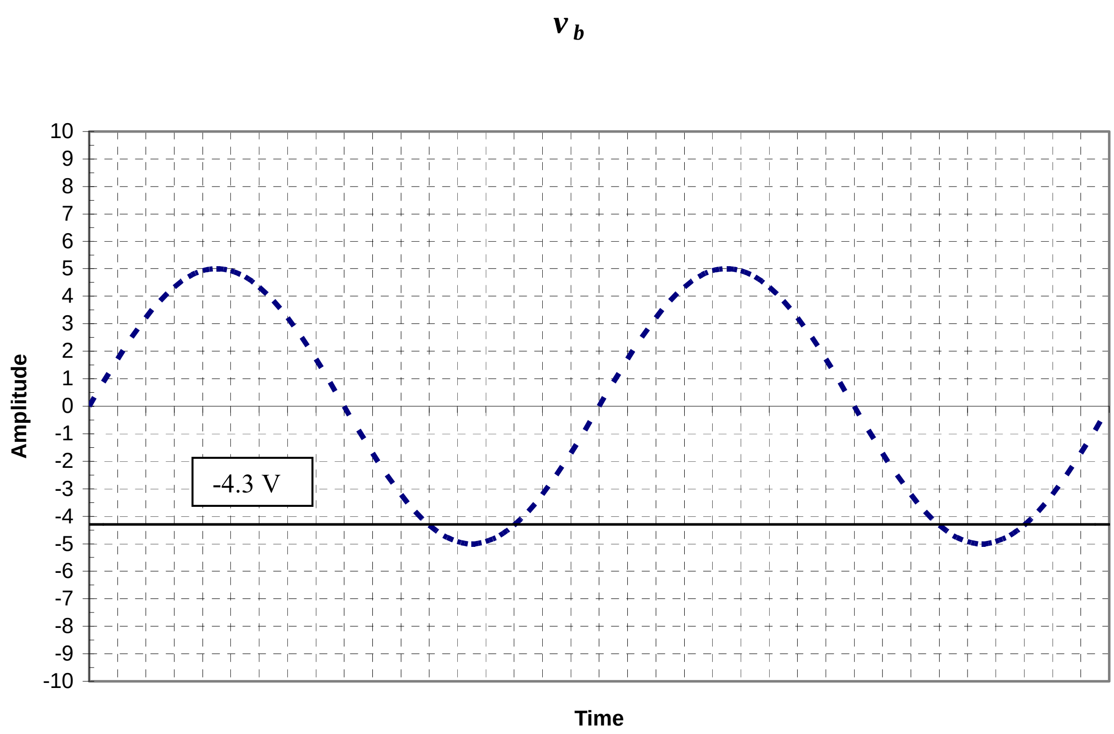


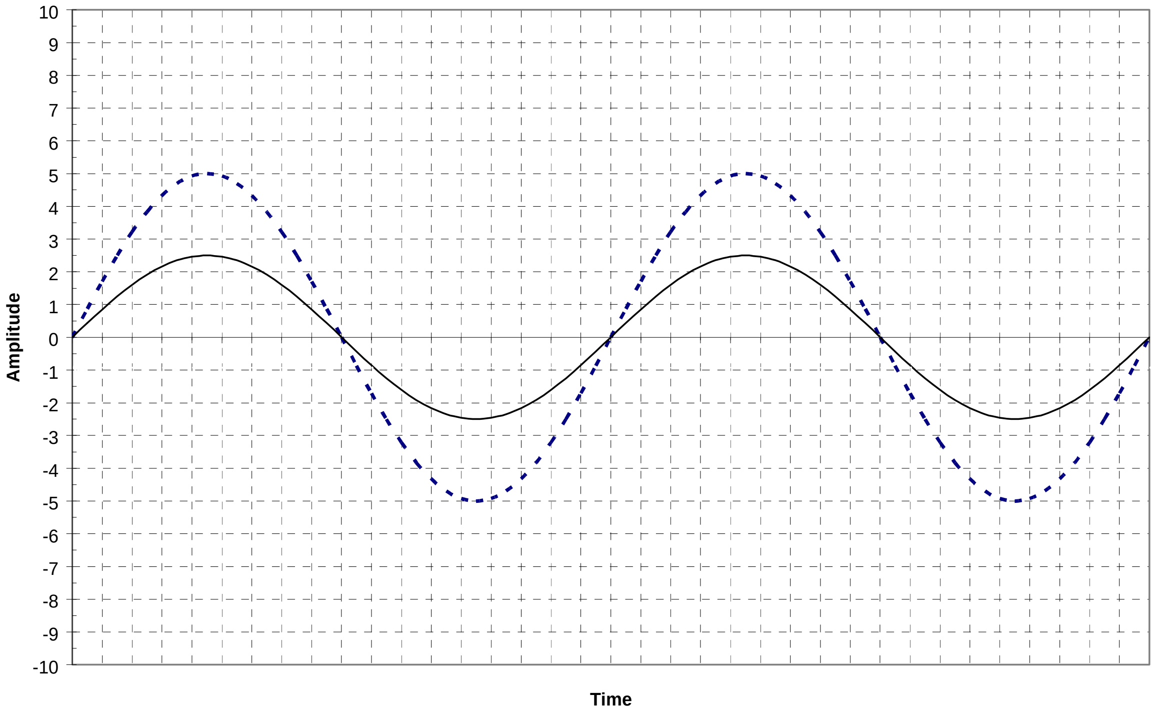
Figure 3

Assume τ is Very large.


v_a
Amplitude
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
Time


v_b
Amplitude
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-4.3 V
Time

v_c


10
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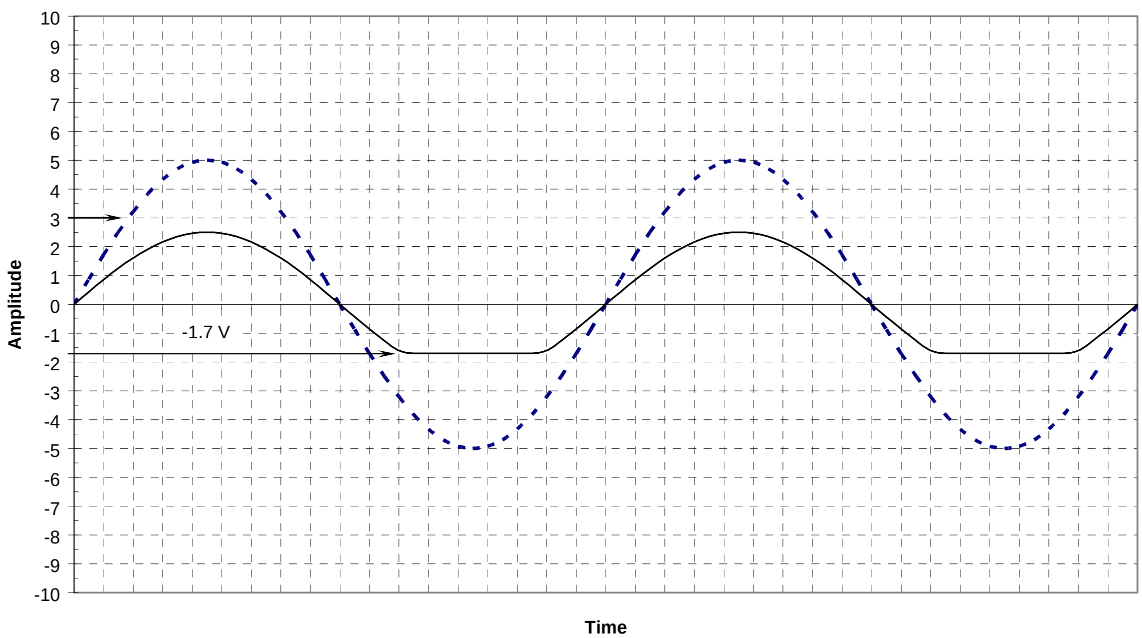
-8
-9
-10
Amplitude
Time

v_{out}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-7
-8
-9
-10
-1.7 V
Amplitude
Time